

## Production of ultracold polar molecules via photoassociation

D. DeMille, A. J. Kerman, J. M. Sage, and S. Sainis, and T. Bergeman\*

*Physics Department, Yale University*

*\*Department of Physics and Astronomy, SUNY Stony Brook*

We have produced ultracold, polar RbCs molecules via photoassociation in a laser-cooled mixture of Rb and Cs atoms [1]. Rb and Cs atoms are trapped in a dual dark-spot magneto-optic trap, at temperature  $T \sim 100 \mu\text{K}$ . We obtain rotationally resolved spectra of weakly-bound RbCs\* states, below the  $\text{Rb}(5s_{1/2}) + \text{Cs}(6p_{1/2})$  threshold, by observing correlated trap loss in both species arising from photoassociation by intense, tunable laser light. We have explicitly verified the polar nature of these RbCs\* states by observing the Stark effect in the rotational spectra. Modeling of the RbCs\* potential curves (see the abstract by T. Bergeman in these proceedings) reproduces the observed rovibrational structure of the photoassociation resonances. From the modeled potential curves (and the known potentials for the RbCs ground state) we can infer substantial decay rates in our experiments into ground state RbCs molecules, and predict in some detail the resulting distribution of vibrational levels in the ground state. Molecules in some of the more highly populated levels could be efficiently transferred to the vibrational ground state using a stimulated Raman transition, resulting in large numbers of stable, ultracold polar molecules.

We will report on our latest work, which is focused on verifying the predictions of our model for the ground-state vibrational distribution, with the ultimate goal of determining an efficient path for production of ultracold polar molecules in their absolute rovibrational ground state. Such a sample of molecules would have wide application, for example as the qubits of a large-scale quantum computer [2]. We now routinely detect ground-state RbCs molecules, created by spontaneous decay following photoassociation, by using resonant (1+1) multiphoton ionization and time-of-flight mass selection of the resulting ions. This has allowed us to explicitly verify that the ground-state RbCs molecules are produced at the temperature of the trapped atoms. We are in the midst of analyzing spectra associated with tuning of the first excitation frequency, which should allow us to extract the desired vibrational distribution. Our latest progress in this direction will be described.

1. A. Kerman, J. Sage, S. Sainis, T. Bergeman and D. DeMille, to appear in Phys. Rev. Lett.
2. D. DeMille, Phys. Rev. Lett. **88**, 067901 (2002).